Predictive
Network-Centric Intelligence:
Toward a Total-Systems Transformation of Analysis and Assessment

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The Need for a Revolution in Assessment Capability

The calm that followed the Cold War is over. Today's war-torn world is wracked by discontinuous change and intense struggle over cultural values and regional power. Rogue states, violent extremism, and devious threat tactics combine with potential access to weapons of mass destruction to pose grave and unprecedented challenges. Security has regained its pre-eminence among national policy concerns, and intelligence, as always, must provide the first line of forward defense.

However, notwithstanding substantial progress in recent years, the United States Intelligence Community (IC) is not yet performing up to its full state-of-the-art potential. Much of official and influential America -- the legislative and executive branches of the federal government, historians, defense analysts, and the informed public – have come increasingly to the conclusion that the IC suffers from systemic deficiencies that must be rectified if warning is to improve.

In addition to the age-old difficulties of penetrating denied areas and ideological movements, we also lack the sophisticated analysis and assessment capability required to convert the extensive information we do collect into prediction and warning sufficiently powerful and timely to prevent intelligence failure and surprise. This incapacity in part reflects the real difficulties of intelligence – but only in part. It also reflects deep-seated institutional culture and venerable but increasingly obsolete beliefs about the supposedly insuperable analytic limitations intelligence organizations face.

This essay argues that intelligence assessment could achieve substantial predictive power, to a degree that greatly exceeds today's standards. It will seek to demonstrate both the need for such a revolution in capability and the feasibility of achieving it, and will outline a strategic program plan to do so. This proposal is designed to implement core elements of the **National Intelligence Strategy**, the **2004 Intelligence Reform Act**, and the recommendations of the **9/11 Commission Report** and related intelligence reform initiatives and studies[1].

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[1] *The National Intelligence Strategy of the United States of America: Transformation through Innovation and Integration*; Office of the Director of National Intelligence, October 2005. National Intelligence Reform Act of 2004 (S.2845, 108th Congress, 6 October 2004). *The 9/11 Commission Report: Final Report of the National Commission on Terrorist Attacks Upon the United States*, Washington, D.C., 2004; W.W. Norton & Co., or http://www.9-11commission.gov/report/index.htm. *Report to the President of the Commission on the Intelligence Capabilities of the United States Regarding Weapons of Mass Destruction*, Washington, DC, 2005; http://www.wmd.gov/report/index.html. Two unofficial reform studies also were important influences inspiring and shaping this proposal: Waltz, Edward: *Knowledge Management in the Intelligence Enterprise*; Artech House, 2003; and Barger, Deborah G.: *Toward a Revolution in Intelligence Affairs*; RAND Technical Report TR-242-CMS, 2005, p. 47; http://www.rand.org/publications/TR/TR242/.

Strategic Vision for Analytic Transformation

'Predictive network-centric intelligence assessment' offers the ability to foresee and warn of threats, be these strategic or tactical and conventional or asymmetric, and either forestall or stay abreast of rapidly breaking crises and high-speed conflict operations. Such enhanced anticipatory power and adaptivity could be achieved through improved analysis and assessment based on current technology and today's collection capabilities. The required methodology and business process involve a structured but adaptive set of procedures involving interagency collaboration, alternative analyses, and the rigorous testing of assumptions and assessments. All three of these elements – community-wide collaboration, expansive creative imagination, and rigorous critical reasoning -- are equally vital. In fact, they are interdependent: a quantum leap in predictive power could come, and could only come, as a synergetic effect of their dynamic integration.

Two basic premises underlie this proposal. First, we trust that promulgated ODNI policy on IC collaboration and information sharing (e.g., relaxed need-to-know constraints) will ensure that web-enabled **virtual collaboration** (e.g., analysts' 'wikis' and 'blogs') will soon become the normal operating mode for analysts sitting at their desks producing daily intelligence across the community. Such baseline collaboration is necessary. The second premise, however, holds that in and of itself such distributed collaboration will not maximize the IC's predictive potential. Much more can and must be done. The IC must also implement powerful new capabilities for **proximate, 'synchronous' collaboration**, and then build from both of these collaborative advances a radical new capability for IC-wide collaboration that exceeds any plans yet promulgated.

The visible centerpiece of this transformed capability would lie in the creation of a **community-wide system of advanced intelligence assessment laboratories** that would operate according to a formal, documented assessment methodology – specifically, **scientific methodology**[2]. Within these labs analytic project teams would use a wide array of both interdisciplinary and problem-specific methods, tools and techniques to produce all-source finished intelligence, while simultaneously advancing the state of the analytic art through experience and lessons-learned. A suitable term for such 'knowledge factories' might be '**computational collaboratories**'.

The premier IC computational collaboratory should be controlled directly by the ODNI, support the national command authority (NCA), and serve as the main engine for fostering interagency teaming on high-level intelligence projects such as National

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[2] A seminal study by Isaac Ben-Israel recommended the application of scientific methodology to intelligence assessment: Ben-Israel, Isaac: "Philosophy and Methodology of Intelligence: the Logic of the Estimate Process"; *Intelligence and National Security*, Vol. 4, No. 4, October 1989, pp. 660-718. Two previous Galileo papers also have called for the application of scientific method to intelligence assessment: Bruce, James: "Dynamic Adaptation: a Twenty-First Century Intelligence Paradigm" (2004); and Pesce, Joseph and Randolph Tauss: "Science and Intelligence Analysis: the Requirement for 'Critical Thinking' Training in the Intelligence Community" (2004).

Intelligence Estimates (NIEs).[3] Eventually the IC should be netted together by a multi-agency complex of such laboratories – a 'system of systems' -- one in each intelligence agency (all-source and single-source), all integrated over a wide-area network at multiple levels of security. The result would be a 'boundaryless' architecture of permanent, pervasive collaboration.[4]

Implementing this proposal would both require and propel a revolution in both the synthetic (creative-imaginative) and analytic (rigorous-critical) dimensions of intelligence assessment, as part of a major advance in the IC's 'analytic culture'.[5] Yet **since it is methodological, managerial and behavioral in nature, this solution would require only modest expenditure in technical systems development and acquisition, infrastructure, or manning levels.** The new methodology would supplement today's standard operating procedure, which, although practical and productive, relies on a risky combination of practices: routinized bureaucratic procedure conjoined with informal, intuitive reasoning. Both of these exacerbate susceptibility to internal bias and adversary deception, and hence increase vulnerability to intelligence failure and surprise.[6]

In sum, then, IC threat anticipation and warning could be improved substantially, affordably, and relatively quickly, should the national leadership act to transform the methodology and systemic processes governing intelligence synthesis, analysis and assessment. Moreover, beyond its immediate value in improving assessment within the disparate agencies of the national IC, the plan proposed herein would both strengthen and integrate the community, accelerate the intelligence cycle rate (the 'optempo' of our 'OODA Loop'),[7] and transform the IC into a unified system of agile learning organizations with a network-centric capability optimally adapted to today's security challenges and intellectual and technological opportunities.

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[3] Pursuant to Sections 123, National Intelligence Council; 145, Office of Alternative Analysis; and 222, Independence of Intelligence, in the 2004 National Intelligence Reform Act.

[4] 'Boundarylessness' – in effect, horizontal integration – was one of the core tenets of CEO Jack Welch's leadership of General Electric, a conglomerate not unlike the IC, in the 1980s-90s. Welch, Jack, with John A. Byrne: *Jack: Straight From the Gut*; Warner Business Books, 2001.

[5] On 'analytic culture', see Johnston, Rob: *Analytic Culture in the U.S. Intelligence Community: an Ethnographic Study*; Central Intelligence Agency Center for the Study of Intelligence (CIA/CSI), 2005.

[6] A burgeoning multidisciplinary literature addresses the problems and causes of intelligence failure. Cognitive psychology has examined the problems of bias in intuitive reasoning. The seminal application to intelligence is Heuer, Richards J., *Psychology of Intelligence Analysis*; CIA/CSI, 1999. Seminal studies of group and governmental error include Janis, Irving L.: *Groupthink: Psychological Studies of Policy Decisions and Fiascoes*; Houghton-Mifflin, 1972/1982, and Jervis, Robert: *Perception and Misperception in International Politics*, Princeton University Press, 1976. Related challenges in the practice of science are addressed in Kuhn, Thomas, *The Structure of Scientific Revolutions*, University of Chicago Press, 1972. The historical literature on intelligence failure is growing as well; a classic case study is Wohlstetter, Roberta: *Pearl Harbor: Warning and Decision*; Stanford University Press, 1962.

[7] Terminology from military command and control theory: operational tempo or 'optempo' refers to the cyclic rate of C4ISR task accomplishment within and among units. The Observation-Orientation-Decision-Action (OODA) Loop was Col. John Boyd's generalization of what we call the 'intelligence cycle' or 'TPED': Tasking, Processing, Exploitation and Dissemination.

The Problem: Meeting the Challenge of Foresight, Anticipation and Warning

Traditional IC Assessment Culture and Practice

'Methodology' refers to the logic governing methods. It derives from an underlying philosophy, particularly in epistemology, the theory of knowledge. Methodology is applied epistemology and takes the form of an integrated theory of assessment that specifies the domain of application, the criteria of truth, the definition of evidence, and the rules for inference. Thus although tools and techniques and even fairly basic methods proliferate in abundance, all of these fall under a very small number of underlying methodologies.

Essentially two logical-factual methodologies exist for understanding the world of physical things and human behavior, one involving informal, and the other formal, methods. The informal methodology can be characterized broadly as **historiography**, the more or less scholarly study of qualitative evidence formulated as words and sentences in natural language. This typically is undertaken by individual scholars or analysts, working independently or compartmentalized under vertical chains of authority ('stovepipes') in offices within bureaucracies. Traditional intelligence assessment methodology has always been historiographical.

By definition, historiography is strictly descriptive ('graphic'). It can be applied to two timeframes, both of them retrospective: the long-term or distant past, this being history proper (in intelligence, this is 'term analysis'); or the short-term or recent past, this being journalism or current intelligence. By its very nature historiography cannot produce reliable inferences or assessments concerning the other important timeframe: *the future*. Historiography cannot predict.

The risks associated with the misapplication of informal, intuitive, retrospective methods to problems of prediction are becoming increasingly well understood. A burgeoning literature has emerged in **cognitive and social psychology**, **perceptions theory** and the **history of science** that describes theory and findings concerning human perception, cognitive 'heuristics' (habituated rules of thumb), mental and institutional 'paradigms' (belief systems) and 'satisficing' (the tendency to opt for quick, seemingly adequate solutions rather than search exhaustively for utility-maximizing solutions[8]). Herbert Simon, Daniel Kahneman and Amos Tversky, Robert Jervis, Irving Janis and

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[8] 'Satisfice': a combination of 'satisfy' and 'suffice'. Distinguished from classical utility maximization. Concept developed in Simon, Herbert A.: "A Behavioral Model of Rational Choice", *Quarterly Journal of Economics*, Vol. LXIX, February 1955, pp. 99-101 (reprinted in Simon, *Models of Man: Social and Rational*; 1957). Note that satisficing often optimizes under conditions of constraint (especially temporal) and can therefore often provide more rational (utility-maximizing) outcomes than can 'paralysis by analysis'.

Thomas Kuhn are pre-eminent names in these fields[9]. Satisficing heuristics employ assumption-based reasoning for the sake of simplicity and efficiency, and are useful under normal circumstances of low risk. They often are optimal, in fact, especially under constraints such as time pressure (as General George S. Patton noted, "A good plan today is better than a perfect plan next week"). Nonetheless, haste and habit have a cost in introducing patterns of bias and error into human reasoning. Moreover, they are highly susceptible to deception and surprise.

Groups and organizations can fall prey to similar decision maladies, which can be summarized broadly under the rubric '**groupthink**', the process whereby group members conform to given assumptions, stifling doubt and debate so as not to disrupt group togetherness.[10] DIA Indications and Warning (I&W) expert Cynthia Grabo notes that "The rejection of evidence incompatible with one's own hypotheses or preconceptions, the refusal to accept or to believe that which is unpleasant or disturbing or which might upset one's superiors – these are far more common failings than most people suspect".[11]

The distinguished Richards J. Heuer, long the leading counter-deception analyst and trainer in the CIA, summarized the findings from cognitive psychology and applied them to the intelligence problem in his aforementioned *Psychology of Intelligence Analysis*. The literature on intelligence and especially on deception and intelligence failure amplify these findings[12].

In sum, then, by their inherent nature, qualitative methodologies such as historiography are incapable of prediction and entail an excessively high risk of error when employed for that purpose – which is precisely what traditional intelligence does, in the U.S. and other countries. The inevitable result, seen time and again, decade in and decade out, is an unnecessarily high rate of intelligence failure and surprise, with no discernable trend line of upward improvement so far.

What then is required for effective anticipation and warning?

Prediction: Process and Prerequisites

CIA has defined intelligence in relevant terms: "Reduced to its simplest terms, intelligence is knowledge and foreknowledge of the world around us – the prelude to

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[9] Daniel Kahneman shared the 2002 Nobel Prize in Economics for his work in cognitive psychology. The multidisciplinary literature here is vast and indispensable. Space constraints restrict full citation, but oft-cited authors include Herbert A. Simon, Daniel Kahnemann, Amos Tversky, Irving L. Janis, Allen Newell, Robert Jervis, Richard E. Nisbett, Lee Ross, Thomas Gilovich, Scott Plouse and Thomas Kuhn (op. cit., fn 3 above)..

[10] Janis, *Groupthink*, op. cit.

[11] Grabo, Cynthia: *Anticipating Surprise: Analysis for Strategic Warning*; Joint Military Intelligence College, Washington, DC, 2002, p. 39.

[12] The literature here as well is substantial, but theory remains underdeveloped. Oft-cited authors include Richard Betts, Michael Handel, Ephraim Kam, James J. Wirtz, Barton Whaley, Donald C. Daniel & Katherine L. Herbig, John Gooch & Amos Perlmutter, Michael Howard, Roy Godson, Roger Hesketh & Nigel West, and Thaddeus Holt.

decisions and action by U.S. policymakers".[13] Foreknowledge, conceived in a scientific, business, or intelligence sense, obviously does not imply psychic clairvoyance or deterministic 'point' prediction. On the contrary, it refers to **rational expectation**: estimative forecasting based on available evidence and formal analytic methods.

Such estimative prediction requires both **creative and critical thinking**, specifically: (1) formal analytic rigor and the explication of assumptions, and (2) perception and understanding across both the *depth* and the *breadth* of a problem domain, each of which imposes its own specific methodological and practical requirements. First we will examine the problems of depth and breadth and then address that of rigor.

Critical Thinking and Analytic Depth

Extension in depth consists of analysis and extrapolation, the projection of patterns and trends into the long- or short-term future based on statistics and mathematical probability. Such trend-projection is typical in the related group of disciplines known as neo-classical eco-nomics, operations research, management science, and de-cision theory. It relies on strict deductive inference from given premises, including the precept that man is a utility-maximizing 'rational actor' ('economic man'). Moreover, 'man' the 'actor' has always explicitly included both the subject of analysis (e.g., a foreign decision-maker) and, implicitly, the subject *perform-ing* the analysis (the analyst). Such methods, although they provide powerful tools for

> **NOTE on TERMINOLOGY:**
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> Understanding intelligence assessment requires clear distinction among related terms such as methodology and methods; analysis, synthesis, and assessment or judgement; and induction, abduction and deduction.
>   Briefly, **methodology** is the logic governing methods. **Synthesis** builds order and unity out of disorder – in this case, theory and models out of sparse or massive data. It encompasses **induction**, the collection and ordering of empirical data, and **abduction**, the generation and selection of **hypotheses** for testing. **Hypothesis testing** in turn involves **deductive analysis**, the isolation of **variables**, definition of **metrics**, and determination of **logical-mathematical relationships** among these. Re-integration and final assessment again involves synthesis, but at a higher level (completing a cycle of the spiral). Synthesis and analysis are complementary opposites, being jointly necessary but individually insufficient for sound assessment. Finally, the term **assessment** refers herein to the entire integrated process of synthesis-analysis-synthesis.

testing, eliminating or justifying propositions, are only as good as their assumptions -- the old 'garbage in, garbage out' or 'GIGO' problem. Yet, as noted above, social scientists and philosophers have revealed limitations and sources of error in human reasoning that make the selection of assumptions a 'non-trivial' task subject to human error. These patterns of error not only cripple qualitative methodology, they also afflict strictly analytico-deductive methods as well, in the following ways.

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[13] "A Consumer's Guide to Intelligence"; CIA Office of Public Affairs, 1999, p. vii.

First, human rationality is 'bounded': limited and often biased by psychological factors involving perception, cognition, emotion, values and personal interest.[14] Busy observers and participants often tend to form images and frame opinions rather hastily and uncritically ('leaping to conclusions' through 'hasty generalization'). These perceptions produce often implicit and inchoate mental images of the world. This subjectivity and tacit imprecision appear to be 'co-dependent', each 'enabling' the other: comfortable biases are best defended if left camouflaged, which in turn protects them even when they're not a source of comfort.

Next, once observers have formed images and framed opinions, they then tend to internalize them, identify with them, personalize them, and defend them against all incoming data and criticism. Thus even sound assumptions persist and can be rendered obsolete by dynamic change in the environment.

When they rest on such dubious premises, even the most powerful analytico-deductive methods lack the ability not only to predict non-linear, revolutionary discontinuities, but even to identify extant and emerging trends well enough reliably to predict even evolutionary change. Until advanced models emerge[15], the intelligence community can prevent surprise (or at least reduce the risk, rate and severity of surprise) only if it can anticipate the innovative, asymmetric, and often-devious gambits an adversary might employ. This requires a very wide span of peripheral vision that can imagine not just conventional contingencies, but plausible unprecedented ones as well – hypotheses and alternative scenarios. This breadth of imagination is a *synthetic* rather than an analytic function. It is what enables us to 'ask the right questions' in the first place.

Creative Thinking and Synthetic Breadth

In surprises, the 'ball comes in out of left field', outside the victim's span of 'peripheral vision' at the time of the event, which often is narrowly focused in a given direction. Surprise thus usually comes in the form of events for which there had been previous evidence that was ignored or dismissed. In Grabo's words: "It is the history of every great warning crisis that the post-mortems have turned up numerous relevant facts or pieces of information which were available but which, for one reason or another, were not considered in making assessments at the time".[16] As noted above, social scientists have explored some of the reasons for this misdirection of attention.

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[14] Simon, Herbert A.; op. cit.

[15] These would have to take the form of complex adaptive systems (CAS) models that produce self-organized emergence and non-linear dynamics. The most promising models available today appear to be those based on the work of Jay Forrester (see, *inter alia*, *Principles of Systems*, Pegasus Communications, 1968/1990, and http://www.systemdynamics.org/). Highly sophisticated CAS models of emergence and evolutionary dynamics (e.g., agent-based models) promise even more powerful capabilities for the future. The Santa Fe Institute (SFI; http://www.santafe.edu/) and New England Complex Systems Institute (NECSI; http://necsi.org/) are good sources for relevant research information.

[16] Grabo, op. cit., p. 9. This thesis underlay much of Wohlstetter's opus (op. cit.); she indicated that much data that appears retrospectively to have constituted clear I&W ('signals', in information theoretic terms) was lost in the surrounding 'noise'. While retrospective criticism can be disparaged as '20/20 hindsight',

However, no rules-governed procedure, algorithm or software exists for ensuring perspicacity, imagination, creativity, and discovery 'on demand'. These are stochastic, wholistic and 'emergent' complex-systems phenomena, thriving through 'self-organized criticality at the edge of order and chaos'.[17] Deterministic, reductionistic analytics do not promote or proliferate hypotheses: on the contrary, as a 'convergent' mode of reasoning, analysis *narrows* focus and *eliminates* hypotheses. Hypothesis generation is the 'art' of science, the domain where intuition and imagination can and must play an indispensable role in science and decision-making. What is required is a reliable method for broadening such 'divergent' reasoning (a process the IC misleadingly refers to as alternative 'analysis'). Much of the rest of the paper proposes a solution to the problem of promoting these synthetic methods.[18]

The underlying prerequisites lie in induction and 'abduction': the collection, collation, and ordering of data, and the process of 'pattern recognition' required to infer hypotheses to explain the data and make predictions based on it.[19] Once these challenges are solved, proper task sequencing requires that this synthetic phase *precede* the deductive analyses described above, for it is here where alternative hypotheses emerge for subsequent testing using the formal analytic methods.

Analytico-Synthetic Integration

Sound forecasting requires that both elements be integrated into a single unified methodology in order to ensure that the full range of potential contingencies, including even seemingly improbable ones, are subjected to full analytic development and rigorous testing. Synthesis and analysis are complementary and in fact interdependent: by itself, creative imagination can posit a wide range of hypothetical scenarios of undetermined plausibility, but cannot test or substantiate them so as either to eliminate them or convert them into forecasts. This conversion requires formalization. In this stage, the assumptions defining the multiple alternative hypotheses are modeled for

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this paper embraces the thesis argued by Bazerman and Watkins that many surprises are predictable and should have come as no surprise. Bazerman, Max and Michael Watkins: *Predictable Surprises: the Disasters You Should Have Seen Coming and How to Prevent Them*; Harvard Business School Press, 2004. See also Watkins and Bazerman: "Predictable Surprises: the Disasters You Should Have Seen Coming"; *Harvard Business Review* (reprint), March 2003.

[17] General and complex systems theory is another discipline with a thriving literature. Good introductions include Von Bertalanffy, Ludwig: *General System Theory: Foundation, Development, Applications*; Braziller, 1968; and Waldrop, Mitchell M.: *Complexity: Life at the Edge of Order and Chaos*; Simon & Schuster, 1992. See also SFI and NECSI, fn. 16 above.

[18] The 9/11 Commission attributed the failure to understand the gravity of the looming terrorist threat to a range of causal factors, prominent among which was a 'failure of imagination'. The methodology proposed herein would implement the commission's call for the IC to 'institutionalize imagination' through a combination of alternative analyses, 'red-teaming' (i.e., red-cell role-playing and simulation gaming), and "rigorous analytic methods" (*9/11 Commission Report*, op. cit., Chapter 11, pp. 344-348).

[19] 'Abduction', a concept generally credited to Charles Sanders Peirce, refers to the formulation and selection of hypotheses. It often is characterized as 'inference to the best explanation'. As such, it is not an alternative to induction and/or deduction. Instead, it interweaves both in complex sequences to derive explanations or predictions.

internal consistency, extrapolated into the future, and compared with known and incoming intelligence evidence. The veracity of such analysis is largely a function of the range of alternative hypotheses generated in the preceding stage. **What is required, then, is a continuous, total-systems feedback loop between synthetic induction and analytic deduction. This organizational learning spiral traditionally has been known as** *scientific method.*

Forging the Solution: Predictive Network-Centric Intelligence Assessment

Scientific Methodology: Principles and Practices

Scientific methodology marries intuitive, open-minded imagination with skeptical standards of proof. Archimedes sat in a bathtub and conceived buoyancy, Newton noted the falling apple and conceived universal gravitation, and equally intuitive inspiration prompted Einstein to ask if space and time might be relative rather than absolute phenomena. But all then subjected their hypotheses to rigorous mathematical formalization and both logical and factual proof, by comparing predictions deducible from the formalized theory with observable empirical data.

In fact, the entire purpose of science is to seek data and infer predictions concerning future outcomes under specified conditions. The purpose of science and the test of its effectiveness lies in prediction that is more accurate, precise and hence reliable than that produced through any other method of investigation and reasoning.

Science achieves this through the union of complementary opposites in both its underlying epistemology (the philosophy of knowledge) and in its methodology. Epistemologically, science unites **empiricism**, the doctrine that experience and observation are the basic data source for physical fact, in complementary interdependence with **rationalism**, the doctrine that logical and mathematical classification and inference are the basic methods required for sound interpretation of observed fact.[20] This 'rational-empirical' epistemology recognizes and exploits the power of deductive methods (logic and mathematics) to order physical facts into meaningful patterns (theories and models) and then project beyond these to make estimates about facts for which we have as yet no empirical data. This is **scientific prediction**, made possible only by the creative tension between rationalism and empiricism and the synergy unleashed by their symbiosis.

To close the rational-empirical loop, science requires that all estimates and assessments (all hypotheses and theories) be *tested*, both rationally, for internal logical

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[20] The literature on the philosophy of science is voluminous. Two overview works can be identified as particularly influential in shaping the present proposal: Cromer, Alan: *Uncommon Sense: the Heretical Nature of Science*; Oxford University Press, 1993; and Losee, John: *An Historical Introduction to the Philosophy of Science*; Oxford University Press, 1972/2001.

and/or mathematical coherence, and empirically, for correspondence with the observable world. This testing is the essence of Francis Bacon's **experimental method**. Informative results either corroborate hypotheses and dictate their retention, directly contradict them, thus dictating their elimination, or (more often) limit their scope of applicability, thus dictating their modification. This process requires multiple alternative and in fact competing hypotheses, since testing, as noted, is a process of elimination.

Scientific Method

'Method' applies methodology to the solution of practical problems. In science, the problem involves the quest for knowledge of the world.[21] In intelligence, the target of interest involves the capabilities and intentions of foreign actors.

Scientific method implements the aforementioned rational-empirical (analytico-synthetic) feedback loop: practitioners observe and measure phenomena of interest and then delineate the relationships among the data through formal theory (systems of logical and/or mathematical propositions formulated as **models** and algorithms). These theories/models then support the deduction of necessary observable implications: 'if these data are true, and this theory/model is valid, then this other observable fact necessarily follows'. Such testable deductions postulate correlation or causation in the form of 'counterfactual conditional propositions' or **hypotheses**, in which the baseline data and theory function as a set of **independent variables** and the expected outcomes are **dependent variables**. These hypotheses are tested first for logico-mathematical coherence and then typically through laboratory experimentation in which independent variables are manipulated and their outcomes are recorded and then compared with field observation (e.g., intelligence collection).

In sciences that study phenomena and systems that cannot be manipulated physically (e.g., the heavens, the Earth, the past and mankind), scientists must substitute laboratory work and models for physical experimentation on real-world specimens. They assemble observable data from the historical record (natural history or human), but they must perform all of their experiments on models. Experimentation on models is known as **simulation**, and is conducted almost entirely on computers. This work is so important in modern science that an entire methodological subdiscipline has emerged called **modeling and simulation (M&S)**.[22]

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[21] In logic and scientific method, again the literature is vast and substantial. Salient authors include, in addition to Aristotle and Francis Bacon, Carl G. Hempel, Rudolf Carnap, Hans Reichenbach, R.B. Braithewaite, Ernst Nagel, Frederick Suppe, John Holland, Colin Howson & Peter Urbach, Hugh G. Gauch, David A. Schum, Paul Thagard, and Edward Waltz (op. cit.). This proposal has been guided in great part by the work of philosophers associated with logical positivism/empiricism, such as Carl Hempel, Hans Reichenbach and Karl Popper.

[22] See, for instance, Casti, John L.: *Would-Be Worlds: How Simulation is Changing the Frontiers of Science*; John Wiley & Sons, 1997; Hausrath, Alfred H.: *Venture Simulation in War, Business and Politics*; McGraw-Hill, 1971, and Schrage, Michael: *Serious Play: How the World's Best Companies Simulate to Innovate*; Harvard Business School Press, 1999.

Predictive Network-Centric Intelligence: Practical Procedures and Infrastructure for Scientific Assessment

Thinking within the 'box' or paradigm of traditional intelligence 'tradecraft' and vertically stovepiped bureaucracy, today's managers attempt to improve imagination by focusing on individual analysts and exhorting them to 'think outside the box'. The social sciences have shown, however, that that approach is likely to yield but little counter-intuitive fruit.

By contrast, modern business management practice has taken a new approach, one that opens a new paradigm for broadening perception and enhancing the likelihood of discovery. This new method focuses on cross-functional **team collaboration**, which combines interdisciplinary, interdepartmental and/or interagency experts in **Integrated Project Teams (IPTs)**. Under the leadership of professional facilitators, modern IPTs use a rapidly developing suite of tools and techniques for the marshalling of available data, structured brainstorming, and the generation of plausible hypotheses concerning alternative futures and contingencies. Collaborative teaming supplies a double-barreled countermeasure against groupthink: first, IPT members bring together multiple frames of reference, which skilled facilitators then elicit, fomenting creative tension, fruitful conflict, cognitive dissonance, discovery, reconceptualization, and organizational learning.[23]

As noted earlier, much current emphasis is placed, rightly, on virtual collaboration. Distributed collaboration, however, especially if asynchronous, is fraught with implementation difficulties, and can never be as dynamic, intensive, rich or fertile as face-to-face interaction. It can commence immediately upon warning, while physical congregation requires travel; however, the difference in potential productivity and optempo thereafter is dramatic.[24] Thus while virtual collaboration must become the new IC 'equilibrium state', it should be punctuated frequently by major lab-based projects for the production of national-level intelligence assessments, especially deep-looking and far-reaching reassessments, and for the resolution of critical controversies and the conduct of crisis- and combat-support operations.

This in turn requires an institutional setting and infrastructure that supplements bureaucratic offices and stovepiped chains of command with a new system of

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[23] For more on collaborative teaming, see Katzenbach, Jon R. and Douglas K. Smith: *The Wisdom of Teams: Creating the High-Performance Organization*; Harvard Business School Press, 1993; Schrage, Michael: *Shared Minds: the New Technologies of Collaboration*; Random House, 1990; and Bennis, Warren G. and Patricia W. Biederman: *Organizing Genius: the Secrets of Creative Collaboration*; Perseus Books, 1997.

[24] Recent research in team performance argues for the continued importance of proximity for team performance maximization. See, *inter alia*, Fischer, Bill and Andy Boynton: "Virtuoso Teams"; *Harvard Business Review*, reprint, July-August 2005, pp. 116-123; Hoegl, Martin and Luigi Proserpio: "Team Proximity and Teamwork in Innovative Projects"; *Research Policy* 33, 2004, pp. 1153-1165; and Freechild, Sage: "Team Building and Team Performance Management", http://www.phoenixrisingcoaching.com/documents/Article-TeamBuildingandTeamPerformance.pdf, 2004 (last accessed 14 September 2006).

horizontal integration within and across organizations and the community as a whole. The optimal solution is an IC-wide network of intelligence assessment laboratories.

The Optimal Setting: the Computational Collaboratory

Unlike vertically integrated bureaucracies, laboratories are the quintessential 'flat', egalitarian organizations, maximizing intercommunication while minimizing managerial friction. Computational collaboratories would be purpose-designed to bring together analysts (substantive intelligence subject-matter experts or SMEs) and methodologists for cycles of synthesis and analysis.[25] Each computational collaboratory would integrate the functions of an 'electronic meeting room', for collaboration, and a 'math lab', for computational analysis, and teams would perform the two activities in iterative succession to propel a spiral of discovery and organizational learning.

Since these computational collaboratories would be designed to stimulate and integrate both creative 'right-brain' and critical 'left-brain' functions, they should be designed in two 'hemispheres'. The right hemisphere would stimulate group dynamics and supply the SMEs with extensive access to classified and open-source databases, with an ergonomic layout that encourages multilateral interchange. There, professional facilitators would coach the teams through the classic 'forming, storming, norming and performing' stages of team development while driving them at an energetic pace through problem-framing, brainstorming and 'sense-making' activities using the numerous informal and semi-formal techniques intelligence methodologists and corporate facilitators have developed.[26]

The resulting mental models, scenarios and hypotheses would then be handed over by the substantive teams to their assigned technical support group in the 'math lab' or 'left hemisphere' of the collaboratory for analytic development ('instantiation' in computational models) and simulation testing. The technical group would consist of methodologists (modelers, experimental designers and statisticians) armed with the requisite mathematical tools (e.g., Bayesian statistics and multi-attribute utility analysis) and simulation models (ideally systems-dynamics models).[27]

Experimental results and findings would then be submitted back to the substantive analytic teams for the next phase of expert review. In this stage of the cycle, facilitators would help the experts generate new hypotheses to replace those eliminated in testing. Senior substantive team leaders would determine when the cycling should be

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[25] As called for by Ron Johnston in "Integrating Methodologists into Teams of Experts", *Studies in Intelligence*, Vol. 47, No. 1, CIA/CSI, 2003, pp. 57-65; see also chapter 5 in his *Analytic Culture in the U.S. Intelligence Community*, op. cit.

[26] Examples include Heuer's Analysis of Competing Hypotheses (ACH), op. cit., chapter 8, Morgan Jones's many techniques (Jones, Morgan: *The Thinker's Toolkit: 14 Powerful Techniques for Problem Solving*; Three Rivers Press, 1995.), and many additional group techniques discussed in the literature on team facilitation.

[27] Collaborative modeling is discussed in Vennix, Jac: *Team Model Building: Facilitating Team Learning Using System Dynamics*; John Wiley & Sons, 1996; and in Morecroft, John D.W., and John D. Sterman (eds): *Modeling for Learning Organizations*; Productivity Press, 2000.

interrupted for summary assessment and reporting, based either on diminishing analytic returns or external requirements.

This process would generate an organizational learning spiral involving initial inductive synthesis, rigorous analysis, and final comprehensive synthesis and intelligence assessment. In fact, twin spirals would ensue: one involving the substantive intelligence issue under investigation and of concern therefore primarily to the intelligence analysts, and the other involving the computational-collaborative methodology itself, which must constantly undergo scrutiny and improvement by the methodologists.

A suitable name for the national intelligence computational collaboratory might be the **Intelligence Training, Assessment and Simulation Center (ITASC)**[28]. Organizationally, none of the substantive analysts need be ODNI personnel; the line IC production centers would supply these visitors to the ITASC. ODNI, though, ought to manage the ITASC and supply its permanent staff of methodologists, technicians and administrators, who would organize and coordinate projects and agendas, facilitate the teams, perform all M&S and analysis, maintain permanent databases, and oversee the drafting of ITASC project reports (e.g., NIEs).

Toward a National Intelligence Computational Collaborative Network

The ITASC and computational collaborative methodology would create an opportunity to unite the entire IC into a single enterprise or 'system of systems' featuring a high degree of 'boundaryless' horizontal integration. Once the ITASC has lain the groundwork, the DNI could direct and resource parallel efforts within the line agencies and commands. Some agencies have prototypes already in place, such as the Battle Lab in the Defense Intelligence Agency (DIA) and the Advanced Analytic Lab (AAL) in the National Security Agency (NSA). Most, however, have not even begun to experiment along these lines. Such intra-agency labs can be more austere than the national center. Each would implement inter-departmental teaming and tools-based analyses within its agency's special areas of responsibility.

Analytic labor in this national intelligence collaborative architecture would be divided according to agency charter. All, however, should function as a node in a national network integrated through the use of unified, documented scientific methodology supported by a unified family of analytic methods and a shared set of models, computational tools, and databases as well as the IT standards and protocols required to ensure full interoperability, data exchange, and scientific replication (a 'plug-and-play' capability necessary for competitive analysis).[29]

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[28] A name inspired by the Joint Forces Command's Joint Training, Analysis and Simulation Center (JTASC) in Suffolk, VA. By contrast with the JTASC, the ITASC would of course address foreign threats and do so across the full civil-military spectrum. Moreover, it would prioritize assessment above training.

[29] The Advanced Research and Development Activity (ARDA) has already begun the development of the requisite infrastructure for the kind of secure wide-area network this IC 'system of systems' would require (not unlike DoD's DARPANet). This program is the Research and Development Experimental

Once in place, such a **National Intelligence Computational Collaborative Network**[30] would enable full-spectrum network-centric intelligence. ITASC-based collaborative projects for the production of major and enduring DNI assessments could then be supplemented by near-real-time global interagency production of current intelligence for strategic and tactical I&W and crisis and operations support.[31] Community watch offices could undertake continuous virtual collaboration over a secure, real-time, distributed network using video teleconferencing (VTC) and a unified set of IT tools and data, creating **a National Operational Intelligence Watch Officers' Network (NOIWON) for the 21st century**. The DNI could mobilize crisis action teams (CATs) in immediate response to contingencies, for action either within the ITASC or across the collaborative net. This high-intensity, high-velocity system-of-systems would divide labor according to agency charter, exchange data packets and outputs multilaterally, and synthesize assessments through web-enabled distributed production and dissemination. Properly implemented, the resulting whole would vastly exceed the sum of the parts, compress the intelligence cycle rate, and improve IC agility and U.S. national-security response capability by an order of magnitude.

Conclusion: the Need for Scientific Methodology and Network Centricity

In summation, then, this paper argues that in order to overcome pervasive, long-standing deficiencies in insight and warning, the national intelligence community must integrate horizontally in structure and function and adopt advanced methodology that is scientific in essence and intensive in execution. We need to:

- Tie the multifarious agencies together into a single virtual organization through IT-enabled data sharing and advanced analytico-synthetic tools and techniques;
- Bring IC analysts together to form IPTs in collaboratories that maximize both the fertility of imagination and the rigor of analysis;
- Maximize rigor by using computational models, metrics and databases, and
- Ensure that team cycles build on previous achievements by capturing all findings in these models and databases.

The implementation challenge will be threefold: meeting standing production requirements while recapitalizing the community, changing from a guild-based craft to a fully modern profession, and graduating from today's largely intuitive pre-scientific

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Collaboration network (RDEC), which currently links 42 IC and DoD components (intelligence producers and users) into a unified distributed environment for the testing and evaluation of advanced tools, data-sharing and collaboration.

[30] Potential acronym: 'NICCNet'.

[31] The ITASC process would implement Grabo's recommendations for effective I&W (op. cit., chapter 8, especially concerning probability judgments, pp. 145-156, and impediments to warning, 163-169).

'tradecraft' to a formal interdisciplinary science of intelligence.[32] As both Thomas Kuhn and Clayton Christensen discuss, such paradigm shifts and disruptive innovations are never easy or uncontroversial. Paradigm shifts involve transitions from periods of 'normal science' operating within established paradigms to 'revolutionary science' that challenges the extant paradigm.[33] Disruptive innovation involves a similar shift from 'sustaining' to 'disruptive' technologies.[34] In both cases, innovation begins in an immature state, its ultimate superiority not at first being obvious. Extensive testing and data are required to bring it to full fruition and prove its superiority to the inevitable legions of doubters. As Galileo Galilei could attest, many potentially lucrative innovations are attacked and suppressed during this time of acute vulnerability.

In intelligence reform, however, the cliché holds: 'failure is not an option'. The national security stakes are too great. Senior leadership can provide the requisite direction, instructions and resources. Middle management must implement the requisite programs and projects. And all of us will be called upon to help propel manifold spirals of intelligence assessment to produce the continuous discovery and learning necessary for American intelligence to adapt to the dynamics, threats, and opportunities of the 21st century.

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[32] On the need to move from guild craftsmanship to full professionalism, see Marrin, Stephen: Intelligence *Analysis: Turning a Craft into a Profession*; International Conference on Intelligence Analysis, May 2005; https://analysis.mitre.org/proceedings/Final_Papers_Files/97_Camera_Ready_Paper.pdf (last accessed 7 December 2006).

[33] Kuhn, Thomas: *The Structure of Scientific Revolutions*; op. cit.

[34] Christensen, Clayton: *The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail*; Harvard Business School Press, 1997.